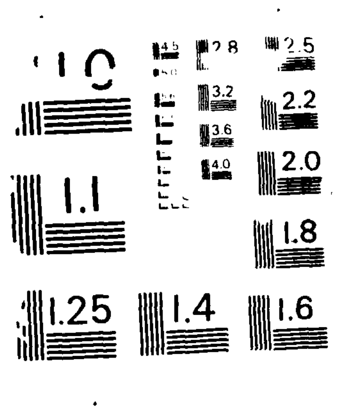
AD-A192 249 ANALYSIS OF BANK STABILITY IN THE DEC (DEMONSTRATION EROSION CONTROL) WATERSHEDS MISSISSIPPI(U) QUEEN MARY COLL LONDON (ENGLAND) C R THORNE 20 JAN 88 1/1

UNCLASSIFIED DAJA45-87-C-0021 F/G 8/8 NL



TEST CHART

STANDARDS

ANALYSIS OF BANK STABILITY IN THE DEC WATERSHEDS, MISSISSIPPI

By

Colin R. Thorne

Queen Mary College, University of London, UK

Contract Number DAJA45-87-C-0021
(R & D 5781-EN-01)

Third Periodic Report

November 1987 - January 1988

The research reported in this document has been made possible through the support and sponsorship of the U.S. Government through

United States Army

EUROPEAN RESEARCH OFFICE OF THE U.S. ARMY

London England

~~This report is intended only for the internal management use by the contractor and the U.S. Government.~~

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
THIRD PERIODIC REPORT

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
ANALYSIS OF BANK STABILITY IN THE DEC WATERSHEDS, MISSISSIPPI

5. TYPE OF REPORT & PERIOD COVERED
THIRD PERIODIC
NOVEMBER 1987 - JANUARY 1988

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
COLIN R. THORNE

8. CONTRACT OR GRANT NUMBER(s)
DAJA45-87-C-0021
(R & D 5781-EN-01)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
QUEEN MARY COLLEGE, UNIVERSITY OF LONDON,
MILE END ROAD, LONDON, E1 4NS, UK

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
EUROPEAN RESEARCH OFFICE OF THE US ARMY,
223 OLD MARYLEBONE ROAD, LONDON, W1 5TH, UK

12. REPORT DATE
20 JANUARY 1988

13. NUMBER OF PAGES
11

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
EROSION, AGGRADATION, DEGRADATION, DEMONSTRATION EROSION CONTROL PROGRAM, MISSISSIPPI, RIVERS, STABILITY, ANALYSIS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is the third periodic report on the contract named in Box 4. It lists the scientific work done on the analysis of bank stability for steep, eroding banks and presents stability charts for banks with gentle slopes. It reports the results of preliminary tests of the analysis for steep banks and outlines research plans for 1988.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

1. SCIENTIFIC WORK DONE

1.1 Logistics

Throughout the third period of study I have been based at the Waterways Experiment Station, Vicksburg. I have continued to develop and test criteria for bank stability, for application to the DEC watersheds. Emphasis has shifted from development to testing during this period. This has involved reduction of existing data supplied by the LMK and acquisition of new data from Long Creek and its tributaries, Goodwin Creek and Johnson Creek. A field trip to North Mississippi was made for data collection in December 1987. Monumented sections were established at 17 points on Long Creek, at 10 points on Goodwin Creek and at 3 points on Johnson Creek. The sites on Goodwin and Johnson Creeks correspond to those used in my 1979/80 study for the USDA-ARS Sedimentation Laboratory. This gives an added dimension to their usefulness. The field data supply information on banks which are generally steeper than those routinely surveyed, and which are known from observation to be close to limiting stability. The field data will be used to test the analytical procedure for predicting bank stability.

1.2 Professional Contacts

The on-going results of the study have been communicated to the sponsors (LMK) and interested parties at WES. They have also been forwarded to, and discussed at length with, scientists and engineers at the remaining active AE, Water Engineering Technology. *Note* - The other AE companies, Northwest Hydraulics and Simons, Li and Associates have now completed their work in the DEC scheme. This sharing of information has been mutually beneficial to the AE's and this researcher, and it should be strongly encouraged in all work of this nature.

1.3 Development of Bank Stability Theory

The HP-41CV program for assessment of bank stability with respect to initial and subsequent failures has been used at WES and at Water Engineering Technology and no new bugs or glitches have been found. Inspection of the code by WET personnel who are very familiar with the HP-41C has confirmed that only minor gains in efficiency could be made with further work on the program and so it appears that we are at the point of diminishing returns in this respect. Therefore no major modifications have been made during this period of study. One problem that has been identified is that of aggradation in the channel decreasing the overall height of the bank between initial and subsequent failures.

When combined with lateral erosion reducing the value of Hi, this can cause the program to crash, if Hi is reduced to zero before failure occurs. This can be accounted for in the program, but as, usually, the analysis is applied to degrading channels the problem should not arise often. It would only occur when upstream bank failures supply so much sediment that the bed aggrades even though the banks continue to be eroded. Whether or not this is a realistic scenario remains to be seen.

A valuable product of the interest shown by WET in the bank study is a version of the stability analysis for the IBM-PC micro-computer. This has been written by Lyle W. Zevenbergen of WET, based on the HP-41CV program and user's manual supplied by me (as reported in the previous section). Lyle used the LOTUS 1-2-3 spread sheet as the basis for the program. Results from his program are being checked against results from the HP program to verify that his program faithfully reproduces the original analysis. So far no discrepancies have been found.

The major advantages of the IBM-PC program over the HP-41 program are:

1) The ease with which variables can be changed. In the LOTUS 1-2-3 spread sheet, any of the input variables (H,Hi,I,phi,c,gamma and K) can be changed at will, and the impact on the factor of safety is seen immediately. This makes it convenient to examine the importance of each parameter - that is the sensitivity of the factor of safety to each variable and;

2) The program runs much more quickly as the IBM-PC has far greater computational power and memory than the HP-41.

The major disadvantages are:

1) The PC is not portable and cannot be used 'on-site'. This limitation does not apply to certain portable PC-clones, but these are comparatively rarely available in the Corps;

2) Availability within the Corps of IBM-PC's with the LOTUS 1-2-3 software is somewhat less than that of HP-41's, even today, and;

3) Although the spread sheet and stability analysis is extremely user friendly, some experience in using the LOTUS 1-2-3 spread sheet is essential to setting-up and running the stability analysis successfully.

My feeling is that the two programs are *complimentary* rather than *competitive* and that both have a role to play in the analysis of bank stability in the DEC watersheds.

I do wish to record my thanks to Lyle for writing the IBM-PC version of the stability analysis and to Chester Watson for giving him the time to do this.

In parallel with development of the stability analysis of steep banks using a slab-type failure mode, I have started looking at the analysis of banks with gentler slopes with regard to failure by rotational slip. In his thesis, my graduate student at Colorado State University, Dr Mohamed Osman presented stability charts for rotational failure of streambanks with gentle slopes (I < 60°), (Osman, 1985). These charts are shown in Figs. 1-3. They define bank stability, failure block width and failure block volume, respectively. To date they have not been tested or applied to real streambanks and so their accuracy and reliability is unknown. I have begun to examine these charts with the intention of applying them to Long Creek and its tributaries.

1.4 Testing the Bank Stability Analysis

Testing of the stability analysis against existing and new data for Long Creek has produced encouraging results. The simplest procedure is to plot the bank heights and angles extracted from the Corps' surveys on a graph together with the line of limiting stability derived from the analysis of initial failures. This plot is shown in Fig. 4. The limiting line delineates two areas of the graph. Below the line is the zone of stability. Banks which plot in this zone should be stable even under the worst combination of circumstances, although banks plotting close to the line would need only minor increases in height or angle to put them at risk of failure. Banks which plot above the line are already "at risk" of failure. Their stability depends worst case conditions not occurring and it cannot be relied upon. These banks would be expected to fail some time in the near future. As expected, the data tend to fall into the "stable" zone as defined by the present analysis. In fact 59 out of 73 points fall on or below the line. The line of limiting stability tends to form an envelope, the bank data following the trend of increasing height with decreasing angle that it defines. 10 banks plot in the "at risk" zone. Further examination of the data indicates that these banks were all located in reaches known to be experiencing rapid bank retreat. Consequently, their "at risk" state is just as expected.

A further test was to plot the lower bank angles observed in the field against bank height. According to the theory reported in the first and second periodic reports, for retreating banks, the lower bank angle should approximate to the failure plane angle, Beta, in the stability analysis, unless the lower bank is mantled by failed bank materials. In that case the lower bank angle

should be less than Beta, by an amount depending on the friction angle of the disturbed material and the degree of basal clean-out by the flow. Fig. 5 shows a plot of H versus lower bank angle, with the theoretical curve for Beta added. The theoretical curve does form an upper bound to the data cloud. This suggests that the lower bank angles are actually equal to or less than Beta, as expected.

2. RESEARCH PLANS

To complete testing of the stability analysis, repeat surveys will be carried out at the field sites on Long, Goodwin and Johnson Creeks in further field trips to North Mississippi. This work will supply the detailed data on the geometry at failure needed to test the full analysis, rather than just the derived curves shown here.

The analysis for banks with gentle slopes will be developed and applied to Long Creek and a user's manual similar to that for the steep banks will be written.

Regionalization of the analysis is planned for the summer of 1988, after completion of the current study and in a new research contract. The relevant proposal is presently in preparation at Queen Mary College.

Discussions regarding the incorporation of the stability analysis into the HEC-6 aggradation/degradation program will be continued and a draft proposal to WES will be prepared.

3. ADMINISTRATIVE ACTIONS

As outlined in the last periodic report Ms Lisa Cheadle joined the project for a 3.5 month period. She has worked diligently and productively both in the field and in the office. Data reduction on the Corps' survey data was undertaken by her, quickly and accurately. Field data collection with her help and that of Terry Waller of WES was accomplished speedily and in a good spirit. She has been a valuable member of the team and the project has benefited from her input and effort. I would like to record my thanks to her for her hard work. She returns to her Ph.D studies at Queen Mary College at the end of this month.

4. REFERENCE

Osman, A.M. (1985) "Channel Width Response to Changes in Flow Hydraulics and Sediment Load." Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Colorado State University, 1985.

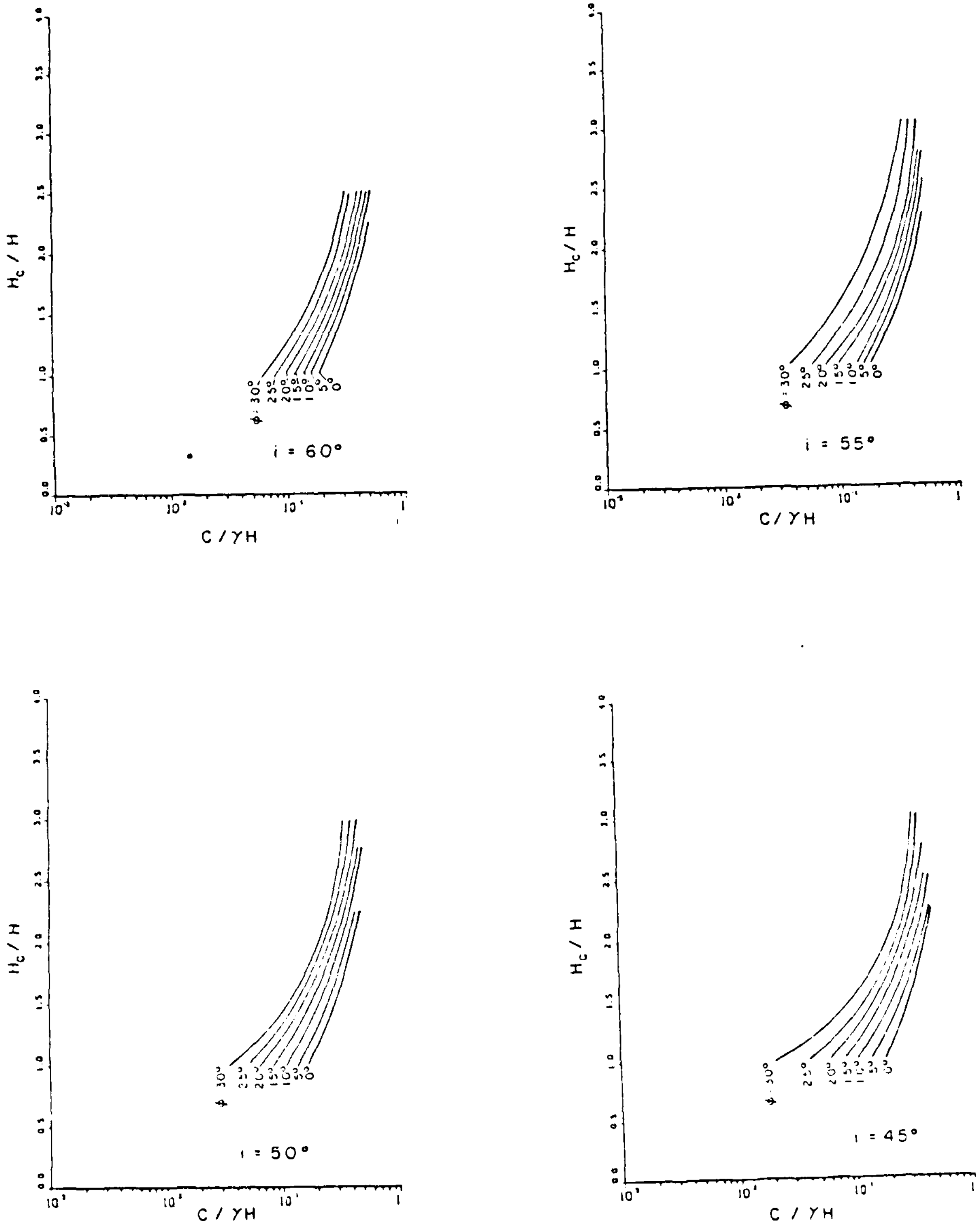


Fig. 1. Stability Charts for Streambanks with gentle slopes (After Osman, 1985). Note Symbols correspond to those in first periodic report.

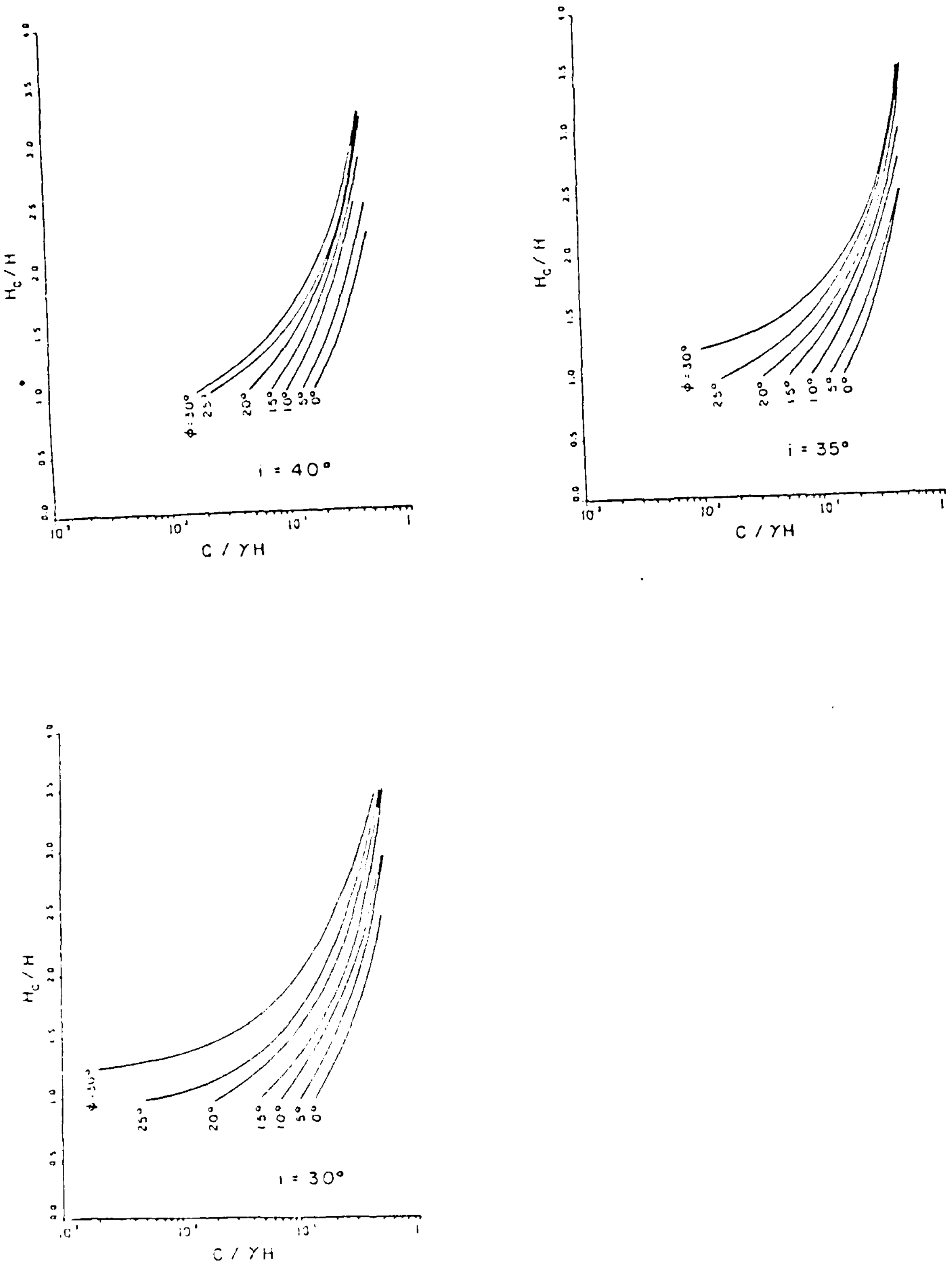


Fig. 1. Continued.

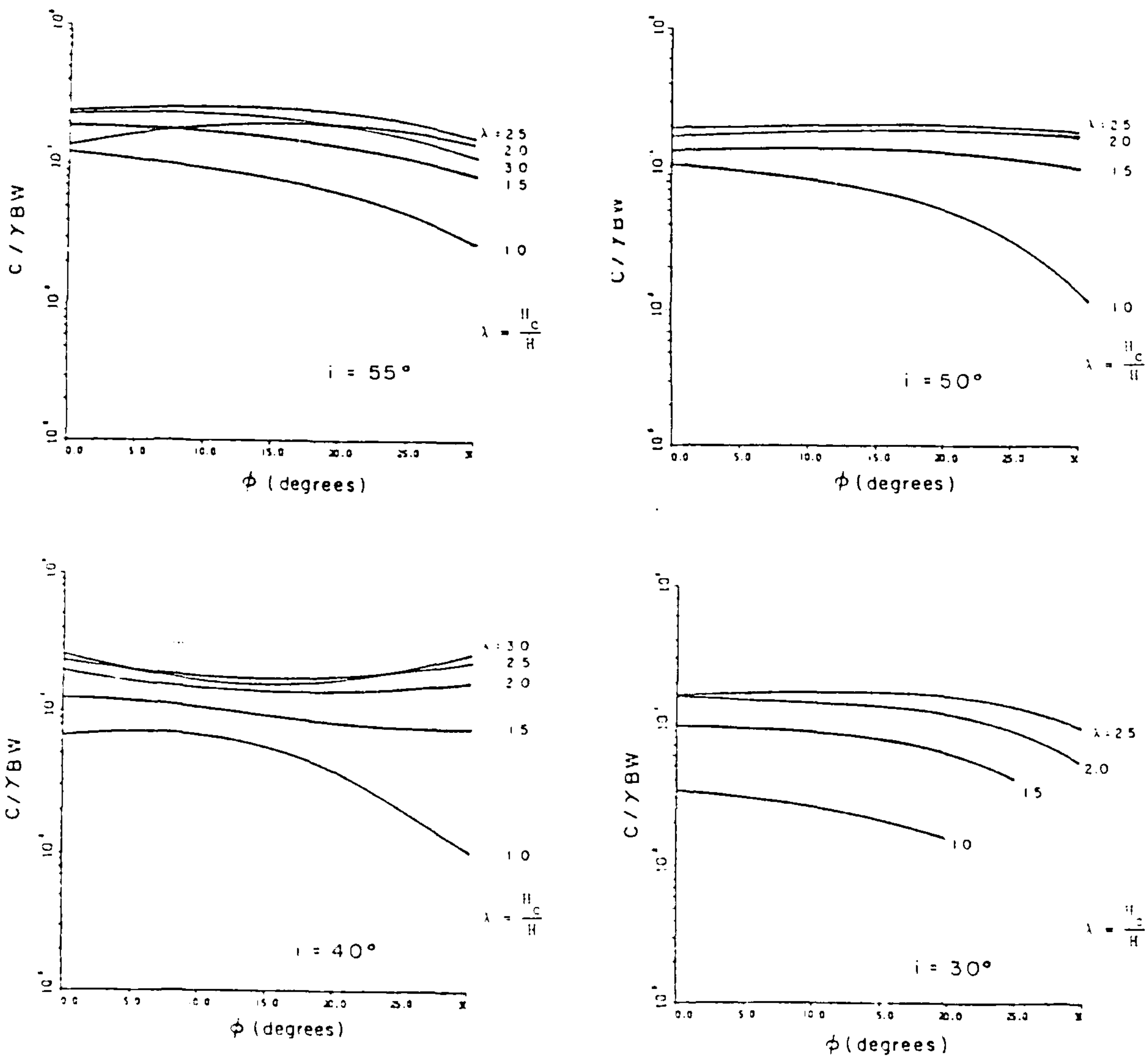


Fig. 2. Prediction of Failure Block Width for Streambanks with gentle slopes (After Osman, 1985).

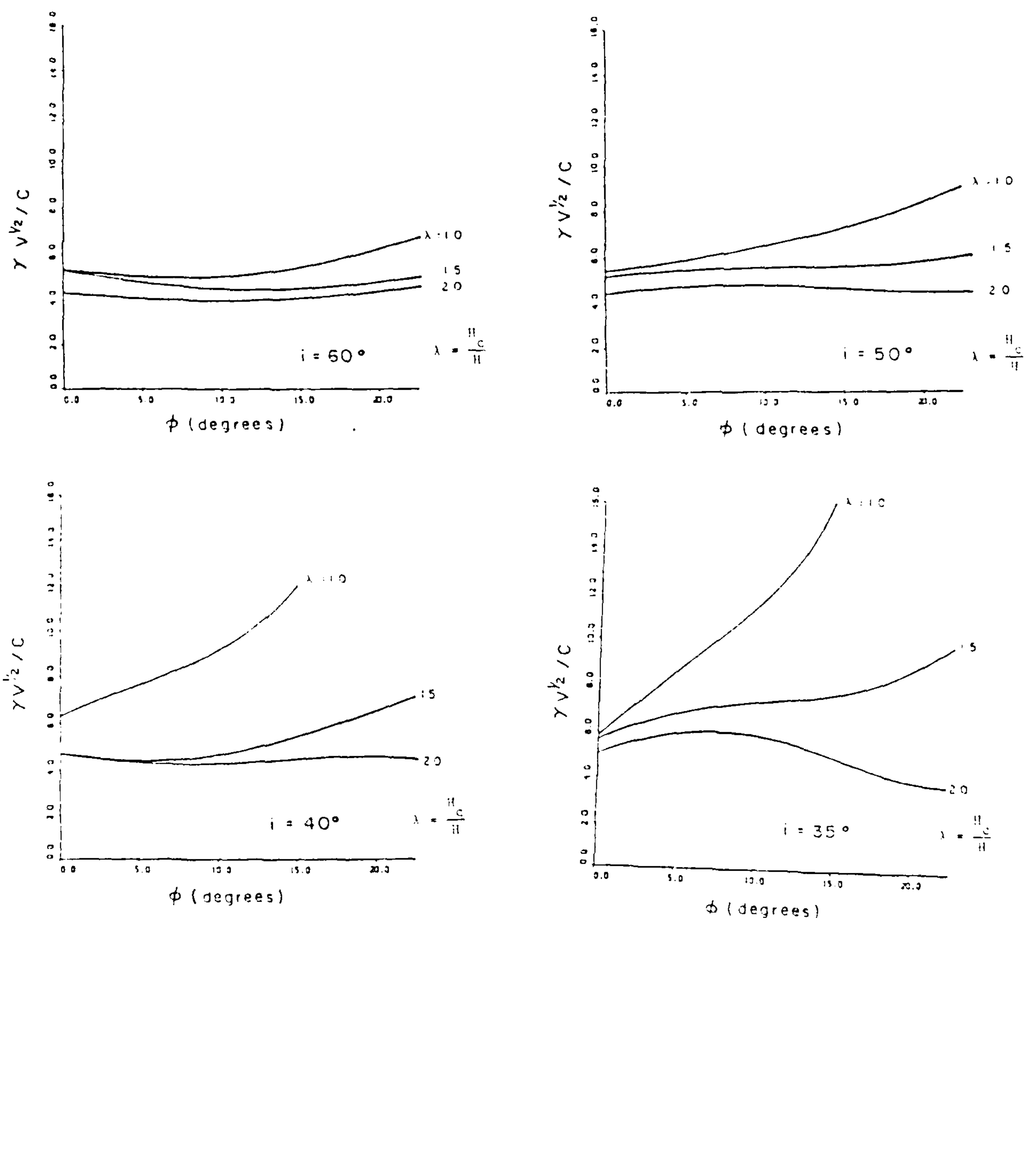


Fig. 3. Prediction of Failure Block Volume for Streambanks with gentle slopes (After Osman, 1985).

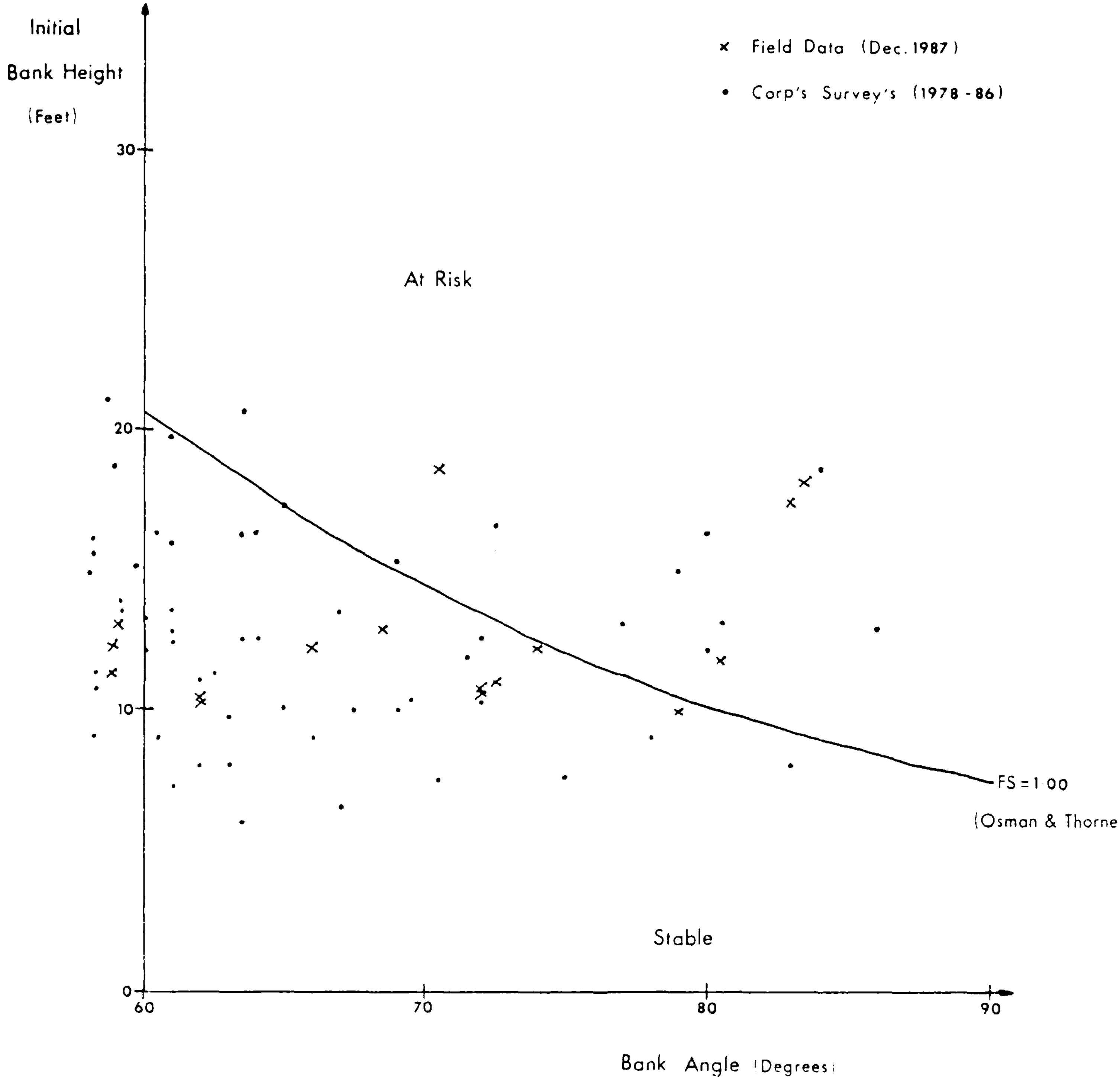


Fig. 4. Observed Bank Heights and angles from Corps' surveys in the Long Creek Watershed between 1978 and 1986, together with the line of limiting satbility for "worst case conditions from the Osman-Thorne stability analysis.

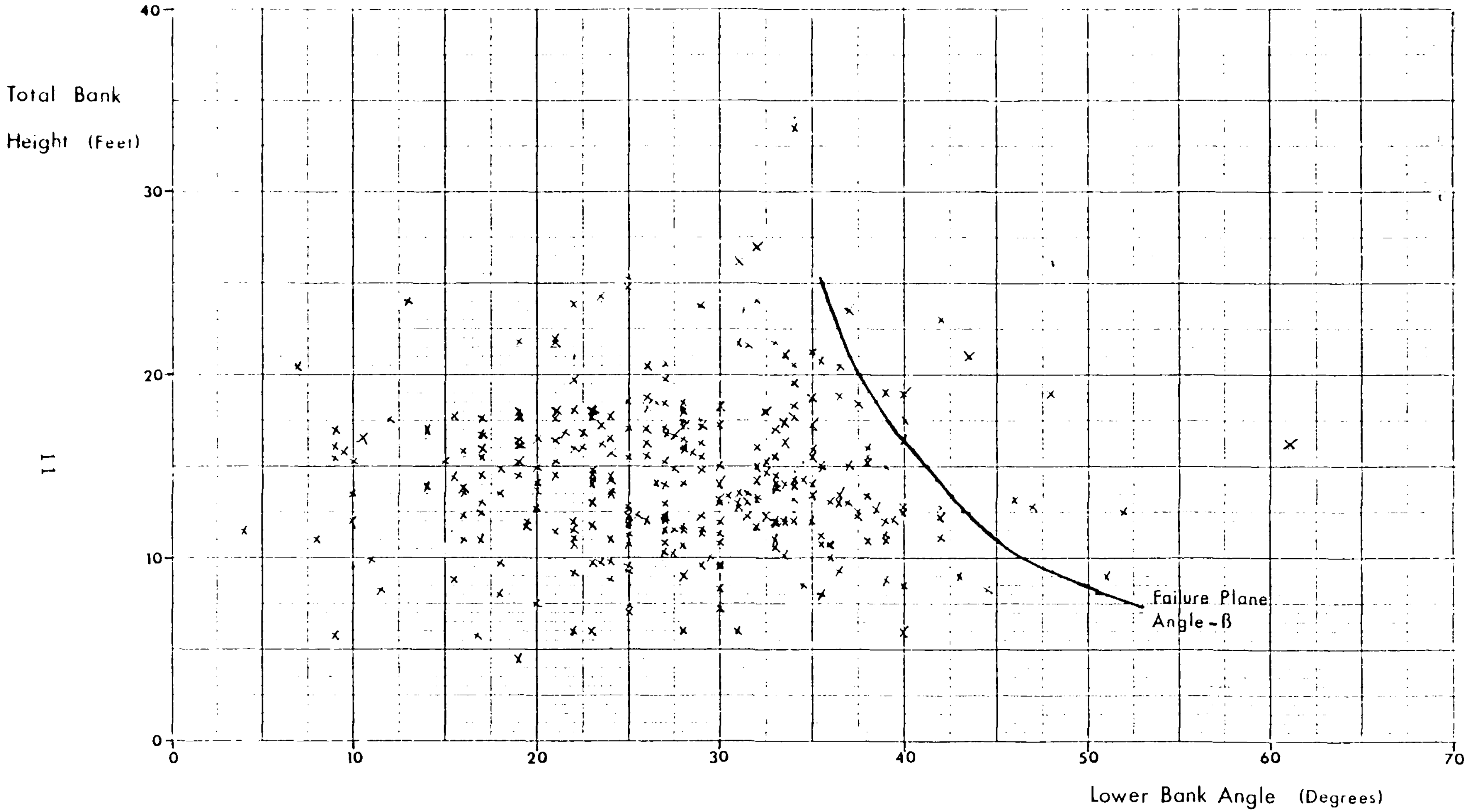


Fig. 5. Observed Bank Heights and lower bank angles from Corps' surveys in the Long Creek Watershed between 1978 and 1986, together with the theoretical curve for failure plane angle Beta for "worst case conditions from the Osman-Thorne stability analysis.

END
DATE
FILMED
6-1988
DTIC